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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Antifriction Screw and Nut Assembly

We, TEXTRON INC., a corporation organised under the laws of the State of Rhode Island, United States of America, of 10 Dorrance Street, Providence, Rhode Island, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

The present invention relates to low friction screw and nut assemblies in which loads are transmitted between a screw and coacting nut by an endless procession of recirculating bearing elements.

A screw and nut assembly according to the present invention comprises a screw having a helical groove; a nut closely encircling the screw, the nut having a helical groove complementing the adjacent portion of the screw groove to define therewith a first passage of helical shape between the screw and nut for receiving load supporting bearing rollers, the screw groove having a first helical surface which is generally straight when viewed in a transverse section of the first passage, the nut groove having a second helical surface disposed in spaced and opposing relation to the first helical surface and being generally straight when viewed in a transverse section of the first passage, means on the nut defining a roller return passage extending between and connected with opposite ends of the first passage to form with the first passage an endless passage for bearing rollers; and endless procession of bearing rollers movably disposed lying adjacent to each other in the endless passage for circulation therethrough upon relative rotation of the nut and screw, all of the rollers in the first passage having a common orientation whereby they all have rolling engagement with both the first and second helical surfaces, the roller return passage having a shape in transverse section which in effect is rectangular to maintain the common orientation of the bearing rollers disposed in and moving through it between opposite ends of the first passage, and having an effective twist therein which enables the return passage to receive circulating rollers from either end of the first passage and discharge them into the other end of the first passage in rolling engagement with both of the first and second helical surfaces.

Examples of screw and nut assemblies according to the present invention are illustrated in the accompanying drawings in which: —

Figure 1 is a side view of a screw and nut assembly;

Figure 2 is a plan view of the assembly of Figure 1 with certain parts sectioned to more clearly indicate the connection between one end of the bearing roller return channel and a helical passage through the nut;

Figure 3 is a bottom view of the assembly of Figure 1 with certain parts sectioned to more clearly show the connection between the other end of the bearing roller return channel and the helical passage through the nut;

Figure 4 is an end view taken on the line 4—4 of Figure 2;

Figure 5 is a view similar to Figure 4 with the bearing roller return channel partly broken away to illustrate bearing rollers at the junction of the channel with one of the helical passage through the nut;

Figure 6 is a fragmentary sectional view taken along the line 6—6 of Figure 4;

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Figure 7 is a longitudinal sectional view taken along the line 7—7 of Figure 2;

Figure 8 is a side view of a screw and nut assembly forming a modified embodiment of the invention, certain parts being partially broken away to show load bearing low friction rollers;

Figure 9 is a perspective view of a length of hollow square stock from which a bearing roller return channel is made;

Figure 10 is a perspective view illustrating a bearing roller return channel after completion of the first step in its fabrication from a length of square stock;

Figure 11 is a perspective view illustrating the channel after completion of a second step in its production;

Figure 12 is a perspective view of the channel after completion of a third step in its production.

Figure 13 is a greatly enlarged sectional view showing a typical bearing roller on load bearing engagement with the coacting screw and nut; and

Figure 14 is a view similar to Figure 13 but illustrating a typical roller slightly crowned to increase its load bearing capability, the crowning of the roller being greatly exaggerated for clarity in illustration.

The low friction screw and nut assembly 20 forming an embodiment of the invention shown in Figures 1 to 7, comprises an elongated screw 22 extending through a central axial bore 24 in a coacting nut 26.

Loads are transmitted between the screw 22 and the nut 25 by means of an endless procession of bearing rollers 28 which make very small the friction between the screw and nut when rotating relatively to each other under load, while at the same time permitting, to great advantage, a large axial load to be carried by a screw and nut assembly of a given size. Moreover, the assembly 20 is capable of high operating speed with great efficiency under heavy loads.

The screw 22 is machined to have a helical groove 30, V-shaped in transverse section. The groove 30 is defined by two helical surfaces 32, 34 on the screw 22. When viewed in a longitudinal axial section of the screw 22, Figure 1, and in Figure 13 the two helical surfaces 32, 34 defining the groove 30 are straight in transverse section and intersect at the bottom of the groove 30 at a ninety degree angle. Each surface 32, 34 is inclined at an angle of approximately forty-five degrees relative to the axis 37 of the screw 22. The two helical surfaces 32, 34 are equal in width and both make the same angle with reference to a line extending through the intersection of the two surfaces 32, 34 perpendicularly to the axis 37.

The nut 26 defines an internal helical groove 36 which opposes and complements the groove 30 in the screw 22 to define therewith a helical passage 38 extending through the nut 26 and being substantially square in transverse section, as can be seen in Figure 7. The helical nut groove 36 is V-shaped in transverse section and is defined by two helical surfaces 40, 42 which are straight as view in transverse section. The two surfaces 40, 42 intersect each other at a right angle and are inclined at equal angles to the axis 37 of the screw 22, which axis is also the axis of the bore 24 in the nut 26.

The helical passage 38 formed by the nut groove 36 and the screw groove 30 contains a succession of closely adjacent bearing rollers 28 of the endless procession of bearing rollers previously mentioned.

Each roller 28 is cylindrical and has rolling contact with one of the two groove defining helical surfaces on the screw 22 and with one of the two groove defining helical surfaces on the nut 26; successive bearing rollers 28 in the passage 38 have a similar orientation with reference to the passage 38. As shown in Figure 7, each roller 28 in the passage 38 has rolling contact with the screw groove surface 34 along the full length of the roller and has rolling contact with the surface 40 along the full length of the roller.

A slight clearance 44 is provided between each end of each roller 28 and the adjacent structure by making the roller so that its length is slightly less than its diameter. The clearance 44 at opposite ends of each roller obviate binding of the roller so that it has free rolling contact with structure defining the passage in which the roller is received. The fact that the rolling engagement of each roller 28 with each of the coacting screw and nut surfaces 34, 40 extends along the full length of the roller enables the roller to sustain a heavy load and transmit a correspondingly large force between the screw 22 and nut 26 without damage to the roller or to either of the helical surfaces 34, 40 on which it rolls.

Rotation of the screw 22 and the nut 26 relative to each other causes the rollers 28 to move through the passage 38 between the screw and nut. Rollers 28 discharged from one end of the passage 38 are returned to the other end of the passage 38 by a roller return channel 46 having a construction which makes for economical manufacture of the assembly 20 and which contributes to efficient high speed operational capabilities of the assembly in use.

As can be seen in Figures 9 to 12, the roller return channel 46 is fashioned from a length of square tubing stock 48, see Figure 9. The length of square stock 48 defines an internal passage 50 of square shape in transverse section which is slightly larger than the passage 38.

From the length 48 of tubing stock, a

roller return channel 46 of generally U-shape is formed in three steps, as can be seen in Figures 10 to 12. The completed return channel 46 has two straight, substantially parallel legs 52, 54 projecting from a connecting portion 56 of the channel.

The first step in forming the channel 46 from a length 48 of tubing consists in bending one end portion of the tube length 48 to lie at ninety degrees in relation to the remaining portion of the tube length 48 and so define the leg 54, as can be seen in Figure 10. The approximately ninety degree bend 58 has somewhat of a "lazy" shape in that the curvature of the bend 58 progressively decreases away from the leg 54, as illustrated in Figure 10.

The second step consists of bending the opposite end portion of the tubing length 48 to define the second leg 52 which is turned perpendicularly to the first leg 54 and generally perpendicularly to the tube portion between the legs 52 and 54 and designated for convenience by the number 56; this is best seen in Figure 11. The approximately ninety degree bend 60 which connects the leg 52 with the tube segment 56 also has a "lazy" shape, in that its curvature progressively decrease away from the leg 52.

The third step in forming the return channel 46 consists of rotating the two legs 52, 54 into parallel relation to each other so as to form a ninety degree twist in the channel portion 56 between the legs 52, 54, as seen in Figure 12. Because of the previously described "lazy" shape of the two bends 58, 60, the portion 56 on the channel 46 is bowed away from the space intervening between the legs 52, 54, so that the channel 46 fits more closely against the generally cylindrical nut 26, as is indicated below.

The two legs 52, 54 of the return channel 46 thus formed are adapted to slide into two parallel channel notches 62, 64 cut into opposite ends of the nut 26. Each notch 62, 64 has a generally V-shape in transverse section, as illustrated in Figure 6.

The two channel notches 62, 64 are located on opposite sides of the axis 37 of the nut bore 24 and extend inwards from the periphery of the nut 26 lying generally parallel to each other and tangentially aligned to adjacent portions of both the helical screw groove and the helical nut groove 36. Thus, the inner ends of the grooves 62, 64 are substantially aligned tangentially with opposite ends of the helical passage 38.

The finished return channel 46 is mounted on the nut 26 so that opposite ends of the passage 50 within the channel 46 register and communicate with opposite ends of the helical passage 38, whereby the channel passage 50 and the helical passage 38 together from an endless passage for the endless procession of bearing rollers 28.

The return channel 46 is mounted on the nut 26 by fitting the channel legs 52, 54 in the nut grooves 62, 64 and suitably securing the channel in place. As seen in Figures 1 to 3, a hold-down strap 66 extending across the central portion of the channel section 56 and secured to the nut 26 serves effectively in conjunction with the grooves 62, 64 to hold the channel in place.

Prior to mounting the channel 46 on the nut 26, the inner ends of the legs 52, 54 are shaped so that upon assembly of the channel on the nut the inner edges of the legs 52, 54 terminate substantially flush with the screw and nut surfaces defining the passage 38, as seen in Figures 2 to 5.

The endless passage for rollers extending through the nut 26 and through the channel 46 is substantially filled with the endless procession of rollers 28. The roller return channel 46 not only accepts rollers from one end of the helical passage 38 and redelivers the rollers to the other end of the passage 38, but it also performs the necessary function of reorienting these rollers for redelivery to the helical passage.

It will be evident upon inspection of Figure 7 that the axis of a roller in one end of the helical passage 38 is turned approximately ninety degrees with reference to the axis of a roller in the opposite end of the passage 38; the twist can be in either sense. As each roller 28 moves through the channel 46 the axis of the roller is turned through the necessary ninety degree angle in moving through the twisted medial portion 56 of the channel, so that the desired reorientation of the roller is effected. The fact that the channel legs 52, 54 remove rollers from the helical passage 38 and return rollers to the helical passage 38 in directions tangential to the helical passage 38 makes for efficient and smooth operation of the assembly, which is made possible by the progressive reorientation of the rollers in moving through the twisted channel segment 56.

The fact that the successive rollers 28 turn in the same direction because of a similar orientation in the helical passage 38 which serves to advantage in making possible a high operating speed capacity for the assembly.

It will be appreciated that the screw 22 and the nut 26 may be connected with a coacting structure (not shown) in any suitable manner depending upon the nature of the application in which the assembly is used; a suitable connecting structure can be integrally formed on the nut 26.

Since all of the bearing rollers 28 roll on the helical screw surface 34 and the helical nut surface 40 shown in the assembly of Figures 1 to 7, the assembly is capable of providing its powerful low friction thrust load sustaining capabilities in only one direc-

tion. As seen in Figure 7, the rollers 28 provide the powerful, substantially frictionless load sustaining capacity for which the assembly is designed when a thrust load acts on the screw 22 to urge the screw to the left relatively to the nut 26. A thrust load on the screw 22 tending to urge the screw to the right relative to the nut 26, as seen in Figure 7, tends to cause the ends of the rollers 28 to abut against the helical screw surface 32 and the helical nut surface 42. The assembly will readily sustain this type of axial load without damage, but does not do so in an almost frictionless manner, as the rollers when subjected to loads in this direction tend to slide on the nut and screw upon rotation of the screw relative to the nut. The modified screw and nut assembly illustrated in Figure 8 is designed to operate in a smooth running manner in two directions and includes two nuts mounted in tandem on the single screw. Component elements of the assembly shown in Figure 8 which are similar to those of the assembly 20 just described are identified with the same reference numbers with the addition of the suffix "a".

The two nuts 26*a* mounted in tandem in the assembly 20*a* are connected together to operate as a single element and are preferably connected in a manner which eliminates back-lash or axial play of the two nuts on the screw 22*a*.

As seen, flanges 70, 72 formed on adjacent ends of the two nuts 26*a* are connected together by an annular series of bolts 74 which serve to hold the two nuts 26*a* against rotation relatively to each other, whilst providing a means for moving the nuts axially relatively to each other to draw the two flanges 70, 72 up against a spacer 76 formed in this instance by a flat annular washer.

The rollers 28*a* in the two nuts 26*a* are differently oriented so that the left nut 26*a* in Figure 8 is capable of sustaining thrust loads of the screw 22*a* acting to the left as viewed in Figure 8, and the right-hand nut 26*a* is capable of sustaining thrust loads of the screw acting to the right as viewed in Figure 8. For this purpose, the rollers 28*a* in the left nut 26*a* are turned to roll on the screw surface 34*a* and on the opposing nut surface 40*a*. The rollers 28*a* in the right-hand nut 26*a* are turned to roll on the screw surface 32*a* and on the opposing nut surface 42*a*.

Axial movement of the two nuts 26*a* by the bolts 74 while the nuts are held against relative rotation preloads the rollers 28*a* in both nuts so as to eliminate any axial play of the two nuts on the screw 22*a*. The degree of preloading is determined by a number of physical relationships, including the thickness of the annular washer 76. The preloading can be increased by reducing the thickness of the washer 76. Alternatively, the annular washer 76 may be replaced by a suitable annular compression spring, such as a Belleville spring. Use of a compression spring in place of the washer 76 permits an increase in the preloading of the nuts 26*a* by simple tightening of the bolts 74. External loads may be applied to the assembly 20*a* by any suitable connecting structure.

As previously indicated, the bearing rollers 28 used in the assembly 20 of Figures 1 to 7 are cylindrical. A typical roller is illustrated in Figure 13. Similar cylindrical rollers are used in the assembly 20*a* of Figure 8. If exceptionally high axial loads are to be carried, the load carrying capacity of the assembly 20, or the assembly 20*a*, can be increased by substitution in place of the straight cylindrical bearing rollers, bearing rollers which are slightly crowned. Slightly crowned rollers are illustrated in Figure 14 in which components similar to those appearing in Figure 13 are identified with the same reference numbers with the addition of the suffix "b". The crowning of the rollers 28*b* illustrated in Figure 14 is greatly exaggerated in the drawings for the purpose of illustration. The rolling surface 80 of each roller 28*b* has a convex curvature, as viewed from one side of the roller, this curvature or "crown" having a radius of the order of twenty to thirty feet.

WHAT WE CLAIM IS:—

1. A screw and nut assembly comprising a screw having a helical groove; a nut closely encircling the screw, the nut having a helical groove complementing the adjacent portion of the screw groove to define therewith a first passage of helical shape between the screw and nut for receiving load supporting bearing rollers, the screw groove having a first helical surface which is generally straight when viewed in a transverse section of the first passage, the nut groove having a second helical surface disposed in spaced and opposing relation to the first helical surface and being generally straight when viewed in a transverse section of the first passage, means on the nut defining a roller return passage extending between and connected with opposite ends of the first passage to form with the first passage an endless passage for bearing rollers; an endless procession of bearing rollers movably disposed lying adjacent to each other in the endless passage for circulation therethrough upon relative rotation of the nut and screw, all of the rollers in the first passage having a common orientation whereby they all have rolling engagement with both the first and second helical surfaces, the roller return passage having a shape in transverse section which in effect is rectangular to maintain the common orientation of the bearing rollers disposed in and moving through it between

opposite ends of the first passage, and having an effective twist therein which enables the return passage to receive circulating rollers from either end of the first passage and discharge them into the other end of the first passage in rolling engagement with both of the first and second helical surfaces.

2. A screw and nut assembly according to claim 1 in which the roller return passage has two generally parallel end portions that connect opposite ends of the first passage and lie generally tangential by to the ends of the first and second helical surfaces, the end portions of the roller return passage being connected by an intervening portion of the roller return passage having a substantial twist therein.

3. A screw and nut assembly according to claim 1 or claim 2 in which the roller return passage is formed by a roller return channel having a generally U-shape, and having two generally parallel end portions connected by a twisted portion of the channel being fitted onto the nut to connect opposite ends of the first passage and lying generally tangentially to the ends of the first and second helical surfaces.

4. A screw and nut assembly according to claim 3 in which the exterior of the roller return channel is rectangular in transverse section, and the end portions of the channel fit into V-shaped notches formed in opposite ends of the nut.

5. A screw and nut assembly according to any of claims 1 to 4 in which a second nut encircles the screw and defines a helical groove complementary to the adjacent portion of the screw groove to define therewith a second passage having a helical shape and lying between the second nut and the screw for receiving load supporting bearing rollers, the screw groove being generally V-shaped in transverse section and defining a third helical surface which is generally perpendicular to the first surface, the groove of the second nut defining a fourth helical surface disposed in spaced opposing relationship to the third helical surface, the third and fourth surfaces each being generally straight when viewed in a transverse section of the second helical passage, there being means on the second nut defining a second roller return passage extending between and connected with opposite ends of the second helical passage to form with the second helical passage a second endless passage for bearing rollers, a second endless procession of bearing rollers movably disposed, and lying adjacent to each other in the second endless passage for circulation therethrough, all of the bearing rollers in the second helical passage having a common orientation whereby the rollers in the second helical passage all have rolling engagement with both the third and fourth helical surfaces, the second roller return passage being shaped and positioned to receive circulating rollers from either end of the second helical passage and discharge rollers into the other end of the second helical passage in rolling engagement with both the third and fourth helical surfaces, and means connecting the two nuts together for their movement in unison with respect to the screw.

6. A screw and nut assembly according to claim 5 in which the means connecting the two nuts together includes means for adjusting the positions of the two nuts in relation to each other to provide optimum engagement of the rollers with their coacting surfaces.

7. The method of making the screw and nut assembly of claim 3 comprising, providing a screw which has a helical groove therein, providing a nut having therein an internal helical groove shaped to complement the screw groove; providing a length of hollow tubing which has a rectangle shape in transverse section; forming a first bend in the tubing length to turn one end portion of the tubing length to lie at a substantially right angle to the other end portion of the tubing length, forming a second bend in the tubing length to turn the other end portion of the tubing to lie substantially at a right angle to the one end portion and at a substantially right angle to the portion of the tubing length lying between the end portions thereof, twisting the portion of the tubing length lying between the end portions to bring the end portions thereof to lie generally parallel to each other; placing the screw in the nut; filling the tubing length and the nut groove with bearing rollers having a common orientation, and mounting the tubing length on the nut so that the two ends of the tubing length connect with opposite ends of the nut groove.

8. A screw and nut assembly as claimed in claim 1 and substantially as described with reference to the accompanying drawings.

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

Fig. 1.

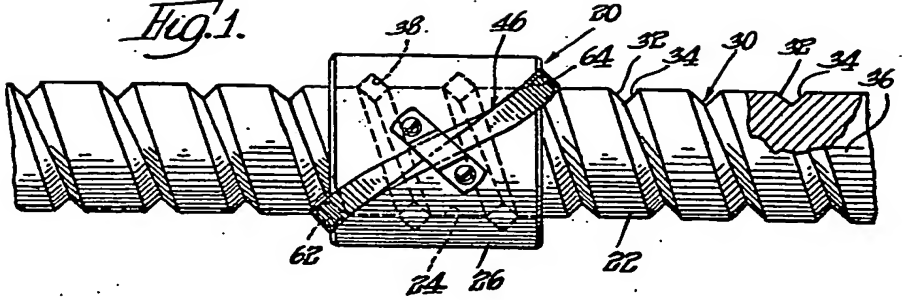

Fig. 2.

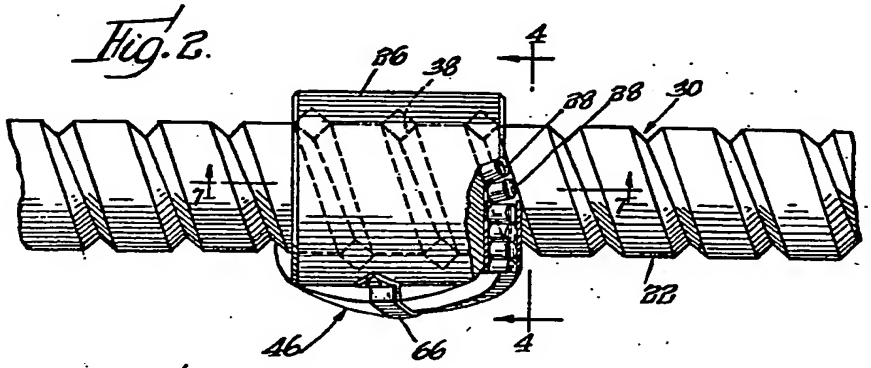

Fig. 3.

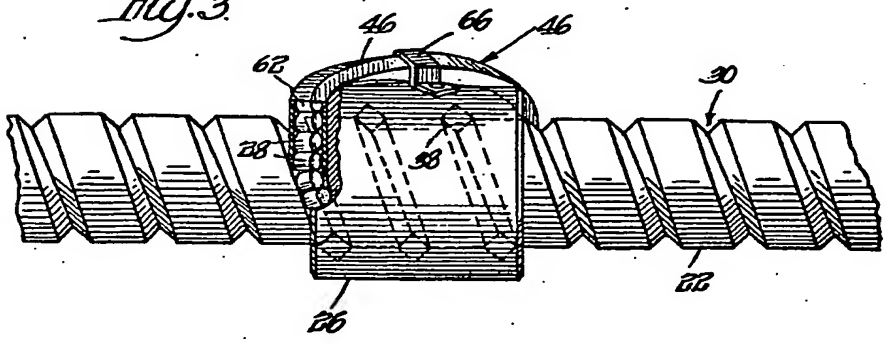

Fig. 4.

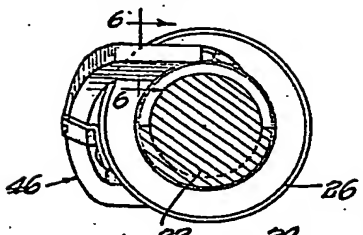

Fig. 5.

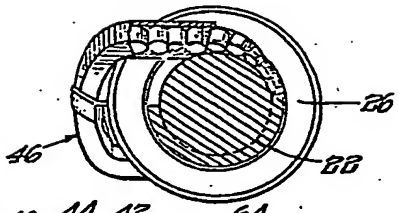

Fig. 7.

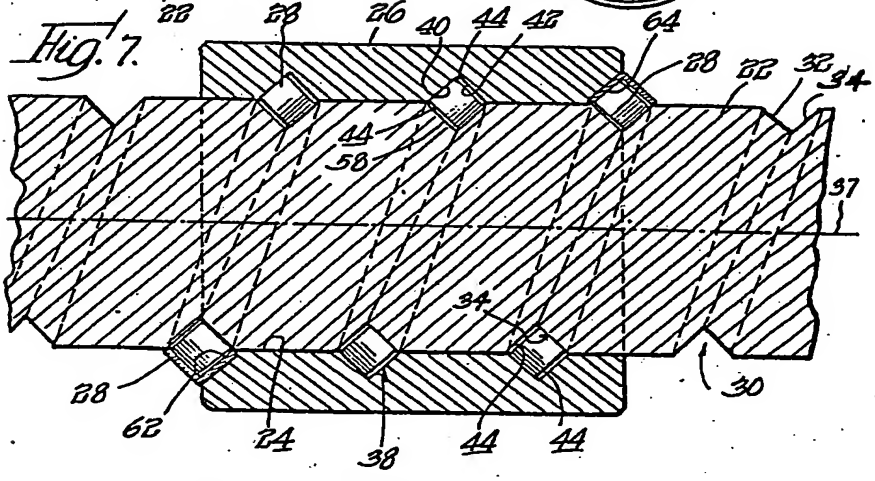

Fig. 6.

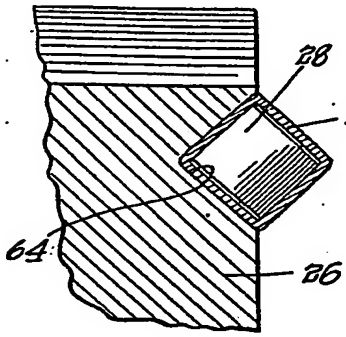

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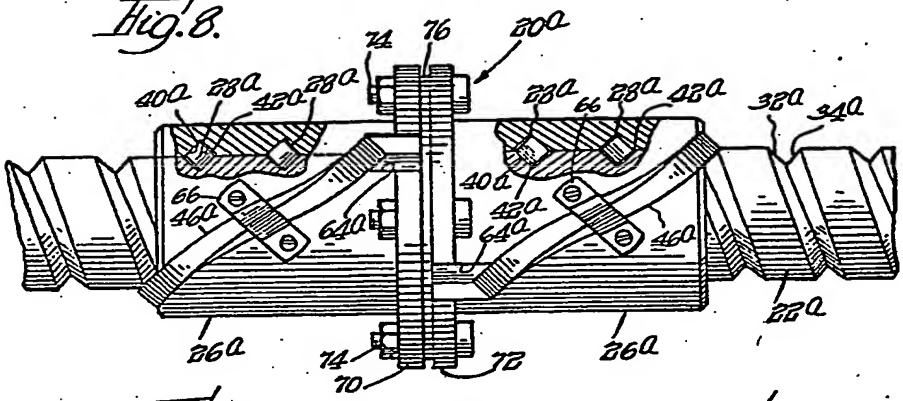
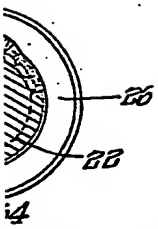
Fig.8.





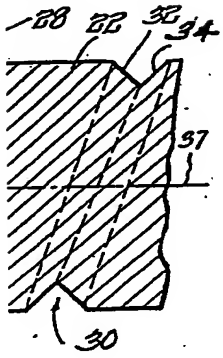


Fig.6.

Fig.9.

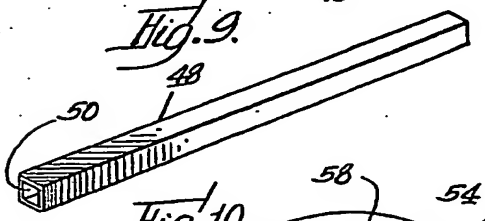


Fig.10.

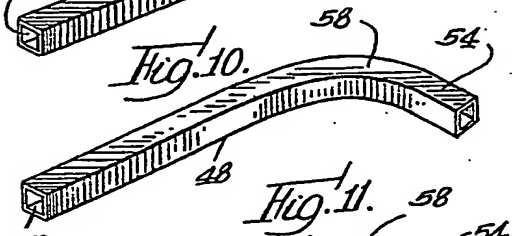


Fig.11.

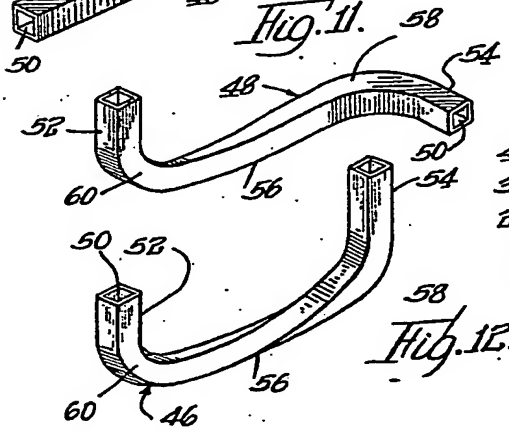


Fig.12.

Fig.13.

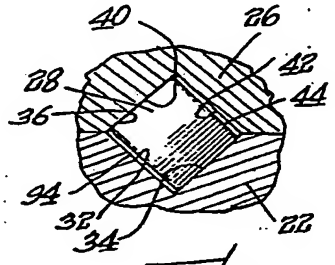
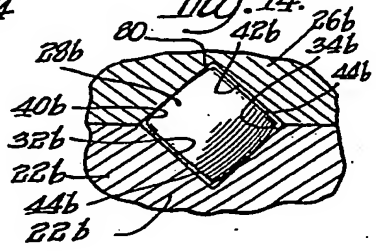


Fig.14.



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